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SUGGESTED SAFETY RULES FOR INSTALLING AND USING ELECTRICAL EQUIPMENT IN BITUMINOUS COAL MINES

BY

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SUGGESTED SAFETY RULES FOR INSTALLING AND USING ELECTRICAL EQUIPMENT IN BITUMINOUS COAL MINES.

By H. H. Clark and C. M. Means.

INTRODUCTION.

This report, presented by the Bureau of Mines with a view to increasing safety in mining, contains a set of rules recommended by the bureau for the installation and use of electrical equipment in bituminous coal mines. The object of publishing these rules is to bring about conditions that will be helpful in reducing the number of accidents from electricity and to urge the use of well-chosen equipment and the adoption of uniform and efficient methods of construction, installation, and maintenance. These rules should be regarded as constructive and not as restrictive, as intended to assist and not to hinder, and should be considered as a suggested guide to the accomplishment of satisfactory results.

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BASIS OF THE RULES.

Five basic measures for safeguarding the use of electricity in mines are as follows:

1. Remove the contributory causes.
2. Remove from the vicinity of electrical apparatus all elements susceptible to the influence of electricity.
3. Keep the electric current where it belongs, if possible. If not, limit the area of its activity by protective devices.
4. Use a large factor of safety in the selection, installation, and inspection of equipment.
5. Have full control of the movements of electrically driven machines.

Each rule that is given in this report is proposed as necessary or helpful to the accomplishment of one or more of these measures.

DEFINITIONS OF TERMS USED.

The meanings of some of the terms and expressions as used in this paper are defined below in order to avoid confusion. The terms so defined are designated with an asterisk (*) in the text.

Alive.—See definition of "live."

Approved.—The term "approved" means accepted as suitable by a competent committee, board, or organization designated by those adopting the rules.

Authorized person.—The term "authorized person" means a person appointed or permitted by the official designated by the State mining laws as the one in charge of the operation of the mine to carry out certain duties incident to the generation, transformation, and distribution or use of electric energy in the mine, such person being one who is competent within the purpose of the rule in which the term is used.

Electric system.—The term "electric system" means all electric apparatus pertaining to the operation of the mine and under the control of the mine officials that is connected electrically to a common source of potential or that is installed so that it can be thus connected.

Explosion proof.—The term "explosion-proof casing or inclosure" means an inclosure that is so constructed and maintained as to prevent the ignition of gas surrounding it by any sparks, flashes, or explosions of gas that may occur within such inclosure.

Gaseous place.—The term "gaseous place" means a place [a] that is likely to be dangerous from the presence of inflammable gas.

Grounded circuit.—The term "grounded circuit" means a circuit that is permanently grounded at one or more points.

Grounding.—The term "grounding" as applied to any object used in connection with a permanently grounded electric system means connecting such object to the earth in such a way that a path of low resistance is provided between the object and the permanently grounded point of the system. A connection to a thoroughly bonded rail is an example of a good ground connection.

The term "grounding" as applied to any object used in connection with an electric system that is not provided with a permanent ground means making a connection to the general mass of earth in such a manner as will insure at all times an immediate discharge of electrical energy without danger.

Ground return.—The term "ground return" means that part of a circuit which is the earth, or metallic conductors intimately associated with the earth, and which is practically at earth potential at all points.

Live.—The word "live" means "charged with electricity" to such a potential as to be in a condition to give a dangerous electric shock.

Portable electric lamps.—Portable electric lamps are electric lamps that while lighted may be carried about. This general term includes lamps operated by batteries and lamps connected to a source of power by a flexible conductor whose length limits the range over which the lamp may be used.

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[a] The word "place" is used here in its broadest sense, and refers to any excavated space anywhere within a mine. It should not be confused with "working place" or "working face."

Self-contained portable electric lamps.—Self-contained portable electric lamps are electric lamps that are operated by an electric battery that is designed to be carried about by the user of the lamp.

Portable motors.—The term "portable motors" means motors that are intended for service here and there as occasion requires and that are so constructed or mounted as to facilitate moving them from place to place.

Stationary motors.—The term "stationary motors" means motors installed in a permanent manner.

Potential.—The words "potential" and "voltage" are synonymous, and mean electrical pressure.

Difference of potential.—The expression "difference of potential" means the difference in electrical pressure existing between any two points in an electrical system or between any point of such a system and the earth, as determined by a voltmeter.

Potential of a circuit.—The potential or voltage of a circuit, machine, or any piece of electrical apparatus means the potential normally existing between the conductors of such circuit or the terminals of such machine or apparatus.

(*a*) Any potential less than 301 volts shall be deemed a low potential.

(*b*) Any potential greater than 301 volts but less than 651 volts shall be deemed a medium potential.

(*c*) Any potential in excess of 651 volts shall be deemed a high potential.

Protected.—The word "protected" as applied to the current-carrying parts of an electric system* is taken to mean that accidental contact with such parts is prevented by approved* guards.

Shock-proof.—The term "shock-proof" as applied to the current-carrying parts of an electric system* (excepting trolley wires) is taken to mean that contact with such parts is prevented by the use of grounded metallic coverings or sheaths.

Generating station.—The term "generating station" means a station in which electric generators are operated by prime movers.

Substation.—The term "substation" means a station in which the current is changed in character, or potential.

Underground station.—The term "underground station" means an underground place in which there are installed transformers, switchboards,* or electrical machines other than portable motors,* or any one of them.

Switchboard.—The term "switchboard" means the essential mounting common to several pieces of switch gear or controlling appliances.

Voltage.—See definition of "potential."

DIVISION 1.—GENERAL RULES.

(For definitions of terms starred with an asterisk see pp. 6–8.)

MAN IN CHARGE OF ELECTRICAL EQUIPMENT.

1. At each mine where electricity is used underground there shall be in charge of the electrical equipment a man fitted for his position by ability, training, and experience. The character of the equipment will determine the qualifications of the mine electrician, and he shall be thoroughly familiar with the operation and maintenance of the equipment under his charge.

PERSONS WORKING ON ELECTRICAL EQUIPMENT.

2. No person shall be allowed to work on or with electrical equipment of any kind unless he has been previously instructed by an authorized person* in the performance of his duties.

CONSTRUCTION AND RATING OF APPARATUS AND RELATION OF CAPACITY TO DUTY.

3. The electrical equipment used in connection with the underground electric system* shall be designed to meet successfully the conditions under which it will be required to operate.

4. All electrical equipment shall be rated in accordance with the current-standardization rules of the American Institute of Electrical Engineers.

5. The rating of each piece of electrical equipment shall be stamped on it or inscribed on a metal plate suitably mounted and maintained upon the equipment. The inscription on the plate shall indicate whether the rating is for continuous or intermittent service and shall be in accordance with the name-plate requirements of the American Institute of Electrical Engineers.

6. The capacity of equipment shall be so related to the work that it has to do that the performance of its duties shall not cause undue heating, straining, or wear and tear.

7. Equipment designed for intermittent service shall not be used for continuous service except at suitably reduced loads.

PERMISSIBLE VOLTAGES.

8. For transmission purposes underground a potential* in excess of medium voltage* may be used, provided that such circuits are carried inside metallic sheaths or coverings with the sheath or covering permanently grounded.* This current may be applied only to transformers or to motors in which the high potential* windings are a part of the stationary element. Medium or low voltage* may be directly applied to all electrical equipment.[a]

MECHANICAL CONSTRUCTION OF INSTALLATIONS.

9. Care shall be taken to insure good mechanical construction and neat workmanship in connection with all wiring and the installation of equipment.

PREVENTION OF ACCIDENTAL CONTACT.

10. Enough space shall be provided for free movement where regular passing is required or permitted around all unprotected* parts of the electric system,*

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[a] It is earnestly recommended that no voltage in excess of low voltage* be applied directly to locomotives, coal-mining machines, or other apparatus of a portable* character.

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and places where persons must pass close to or adjust permanently installed electrical machinery shall be sufficiently lighted.

11. The standing room around all electrical equipment shall be kept as dry as practicable. At any place where it is necessary to manipulate or adjust medium or high voltage live equipment, including switches, motor starters, and other controlling appliances, excepting locomotives and machines that are moved so frequently that they are provided with trailing cables, there shall be provided and available an insulated platform or mat which may be of a form and character most in keeping with the circumstances of its use, and which shall be not less effective than a dry board 3 feet by 15 inches by ⅞ inch.

12. All metallic frames, casings, and coverings, except those of mining machines and drills, that may become alive * shall be permanently grounded.* [a]

13. Where danger exists of accidental contact with wires carrying electric current the wiring shall be protected.* In haulage roads used as traveling ways the wires need not be protected * if a traveling way of approved * dimensions is provided on the side of the entry opposite from the wires. Where wires are run in an entry in which no one but authorized persons * are allowed to travel, or where no hazard from contact exists, the wires need not be protected.*

14. Weatherproof varnished cloth, rubber, or similar insulation, unless inclosed in a metallic sheath, when used underground will not be considered as a protection against shock.

15. In untraveled places where the roof is likely to fall all electrical conductors shall be especially protected from injury by falling roof.

CARRYING CAPACITY OF CONDUCTORS.

16. The carrying capacity of insulated conductors of distributing circuits shall be determined by reference to the table of carrying capacities laid down in the National Electric Code.

The carrying capacity of bare conductors shall be determined by reference to Table 1 following:

TABLE 1.—*Current-carrying capacity of bare copper conductors used in mines.*

Size of conductor.	Current capacity.	Size of conductor.	Current capacity.	Size of conductor.	Current capacity.
B. & S. gage.	*Amperes.*	*Circular mils.*	*Amperes.*	*Circular mils.*	*Amperes.*
10	80	250,000	690	750,000	1,520
8	105	300,000	790	800,000	1,590
6	145	350,000	880	850,000	1,660
4	210	400,000	965	900,000	1,730
2	280	450,000	1,050	950,000	1,800
1	320	500,000	1,140	1,000,000	1,870
0	375	550,000	1,215		
00	435	600,000	1,285		
000	525	650,000	1,370		
0000	615	700,000	1,450		

ELECTRICAL EQUIPMENT IN GASEOUS PLACES*.

17. Only explosion-proof* equipment and wire insulated not less effectively than with three approved* weatherproof braids shall be used in gaseous places* in a mine.

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[a] It is assumed that the ordinary conditions of operation of locomotives fulfill the requirement of this rule.

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See also rules 56, 69, 75, 105, 111, 123, 128 to 136, 140, 142, 144, 145, 148, and 168.

INSPECTION AND MAINTENANCE.

18. At each mine where electricity is used underground a systematic inspection of all wiring and equipment shall be made at regular intervals, at least once every month. A report of each inspection shall be made by the mine electrician or inspector and a copy of this report shall be furnished to the mine foreman and kept on file at the mine. The report shall definitely state the condition of each underground station*, of the conductors and controlling appliances of each main and branch, power and lighting circuit, and of the motors and controlling appliances of each locomotive, mining machine, pump, hoist, or other piece of electrical apparatus connected to the electrical system* of the mine.

NOTICES AND WARNINGS.

19. Caution notices shall be posted at points where such warnings will be most effective in reducing the likelihood of contact, and prohibitory notices shall be posted wherever electrical apparatus that should not be manipulated by unauthorized persons* is installed.

INSTRUCTION FOR RESUSCITATION.[a]

20. There shall be posted prominently in every surface and underground station* and at the entrance to the mine, instructions for the restoration of persons suffering from electric shock.

All employees who work with or on electrical apparatus must know how to carry out these instructions without delay.

PLAN MAP OF ELECTRICAL SYSTEM.

21. A plan shall be kept at the mine showing the location of all permanently installed electrical machinery and apparatus in connection with the mine electrical system*, including cables, conductors, lights, motors, switches, trolley lines, and transformers. The plan shall be of sufficient size to show clearly the location of such apparatus, and the scale shall be not less than 200 feet per inch. There shall be stated on the plan the capacity in horsepower or kilowatts of each motor and transformer and the nature of its duty. Such plan shall be corrected as often as may be necessary to keep it up to date at intervals not exceeding six months.

FIRE PROTECTION.

22. Buckets filled with clean dry sand shall be kept in all underground stations* for immediate use in extinguishing fires. The minimum amount of sand thus stored in any one station shall be not less than 2 cubic feet. No sand will be required if two or more approved* fire extinguishers are kept in each station*.

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[a] See Cannon, W. B., and others, Report of the Committee on Resuscitation from Mine Gases: Tech. Paper 77, Bureau of Mines, 1914, pp. 15–17; Lynott, W. A., and Harrington, D., Elementary first aid for miners: Miners' Circular 23, Bureau of Mines, 1916, pp. 20–22.

DIVISION 2.—SURFACE AND UNDERGROUND STATIONS.

GENERATING STATIONS AND SURFACE SUBSTATIONS.

GENERAL RULES OF SAFETY.

See rules 10 to 13, inclusive.

GENERATORS.

23. Generators shall be installed upon adequate foundations in a dry place free from explosive vapors or inflammable material.

24. Machines generating a potential* in excess of low voltage* shall not have exposed terminals.

SWITCHBOARDS AND CONTROLLING APPLIANCES.

See rules 40 to 46, inclusive.

PROTECTION OF CIRCUITS LEADING UNDERGROUND.

See rules 77 and 78.

LIGHTNING ARRESTERS.

25. Each outgoing circuit that leads underground and extends over the surface of the ground 500 feet or more from the generating station* or substation* shall be equipped with lightning arresters of approved* type, with proper ground connection, at the generating station or substation and also at the point where the circuit enters the mine.

26. Lightning arresters shall be connected on the secondary side of all transformers that feed underground circuits unless there is provided other suitable means for discharging abnormal voltages.

ELECTRICALLY DRIVEN VENTILATING FAN—HOUSING, POWER SUPPLY, AND ATTENDANT.

FIREPROOF BUILDINGS.

27. All electrically driven mine ventilating fans, together with the housing of the motor, shall be built of fireproof materials.

Underground electric fans shall not be used where the air current is rated as gaseous, and when used in nongaseous places the surroundings shall be fireproofed within a radius of 15 feet from the motor unless this has a permissible explosion-proof casing.

POWER SUPPLY.

28. If the line supplying the power is exposed to the influence of lightning, lightning arresters shall be placed near the point where the wires enter the fan house.

29. Where stopping the fan would place in jeopardy the lives of men underground, a duplicate connection from the fan to the power supply shall be provided on a separate line of poles if the regular line is so exposed as to be liable to failure, except at mines where a reserve source of mechanical power is installed for operating the fan. If the regular source of power is from a station

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where there is but one generator a connection to another source of electric power shall be provided, unless there is a source of mechanical power in reserve.

ATTENDANT.

30. The responsibility for the operation of electrically driven mine-ventilating fans shall devolve upon an authorized* person.

ELECTRICAL EQUIPMENT ON TIPPLES AND OTHER SURFACE STRUCTURES.

31. All electrical equipment on tipples and other surface structures shall be installed in accordance with the rules of the National Board of Fire Underwriters.

32. Starters of motors on tipples shall be provided with a no-voltage release, and if practicable shall be located within sight of the motors that they control or the machines that they operate. A switch or other means for disconnecting the motor from the power supply shall be installed near the machinery.

UNDERGROUND STATIONS.*

GENERAL RULES OF SAFETY.

See also rules 10 to 13, inclusive, and rule 22.

33. All underground stations* shall be fireproof and well ventilated with fresh air, and shall be wired in accordance with the requirements of the National Board of Underwriters.

34. Ventilation may be accomplished through openings in the walls, but, with the exception of underground stations* in which only switches are installed, the openings shall be provided with noncombustible doors that will either close automatically in case of fire or can be closed easily from outside the room by the attendant. Underground transformer stations* need not be provided with fire doors if the transformer casings will withstand red heat without their seams opening, and are equipped with explosion doors that will relieve the pressure of an explosion within the casing and automatically close again and exclude air from the casing.

TRANSFORMER STATIONS.

See also "Underground Transformers" (p. 17), and rules 34, 40 to 46 inclusive, 80, and 81.

35. Transformer stations shall be so arranged that if a transformer explodes the oil will not flow outside the room.

36. Wires shall be carried on noncombustible supporting framework and the use of wood shall be entirely eliminated. The supporting framework shall be grounded*.

37. All transformers in excess of 50-kilowatt capacity shall be equipped with suitable ammeters in either the primary or secondary circuits, or have provision for connecting portable instruments into such circuits.

PUMP STATIONS.

See also rules 54 to 68, inclusive.

38. Pump motors operating at potentials* exceeding the limits of low voltage shall be wired inside the pump station with approved* wires carried in conduit sealed to exclude moisture or sheathed with lead and so placed or protected as to avoid mechanical injury. The metallic covering shall be permanently grounded*.

BATTERY-CHARGING STATION.

See also rules 33 and 34.

39. Battery-charging stations shall be provided with approved* means for the immediate removal of the gases generated during the process of charging the batteries.

HOIST STATIONS.

See "General Rules of Safety for Underground Stations" (pp. 13–14), rule 38, and rules 54 to 68.

DIVISION 3.—MACHINES AND APPARATUS.

GENERAL RULES FOR SAFETY.

See rules 3 to 8.

SWITCHBOARDS.*

See also rules 59 to 68 and 76 to 81.

40. Switchboards* shall consist of a substantial framework of iron pipe, angle irons, or bar iron, on which shall be mounted a panel or panels of incombustible, nonabsorbent insulating material that is mechanically strong and has insulating qualities suitable for the voltage* at which it is used.

41. The panels of insulating material may be omitted if each piece of equipment carried on the switchboard* is provided with an individual base of insulating material of the character specified for the panels and of adequate dimensions, or has its current-carrying parts mounted on similar insulation self-contained in the equipment, which shall be especially designed for mounting on iron-pipe, angle-iron, or bar-iron frameworks.

42. A passageway not less than 3 feet wide shall be provided in front of low and medium voltage* switchboards,* and a similar passageway behind such boards if there are connections that can not be manipulated or repaired without going behind the switchboard.

43. Where the potential* of the power supply exceeds the limits of medium voltage* there shall be no unprotected,* live,* high-potential* metal work on the front of the switchboard within 7 feet of the floor, and the space provided for passageways in front and behind the switchboard shall be not less than 4 feet, clear of all apparatus.

44. Conductors shall not cross the passageways back of switchboards* except below the floor or at a height of 6½ feet above the floor.

45. The space behind underground high-voltage* switchboards* shall be kept locked if there are unprotected* terminals or conductors back of the switchboard.

46. There shall be provided for each generator an ammeter of suitable capacity, and for all generators a voltmeter that by closing a switch or manipulating a plug connection can be connected to any generator.

ELECTRIC VENTILATING FAN EQUIPMENT.

HOUSING AND POWER SUPPLY.

See rules 27 to 29.

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CAPACITY OF MOTORS.

47. Motors that operate ventilating fans shall be of sufficient capacity to drive the fan at the maximum speed of the motor under normal conditions of service without overloading.

CONTROL OF MOTORS.

48. Nonautomatic motor-controlling appliances that are used with motors that are not self-starting shall be so arranged that the motor will be disconnected automatically from the supply circuit in case the power supply fails.

ELECTRIC HOISTING EQUIPMENT.

SHAFT HOISTS.

49. All electrically operated shaft hoists that are used for handling men shall, if not provided with a mechanical overwinding device, be provided with an approved* electrical device that will prevent overwinding at the man landing.

50. Shaft hoists shall have a hand brake that will keep the hoisting drum under the control of the operator. This brake shall be provided with an automatic trip or release that will apply the brake in case the power supply fails.

51. Hoists used for handling men shall be so arranged that the speed shall not exceed the legal rate of hoisting when men are being hoisted. If hoists are designed to operate in balance the driving motor shall be of sufficient size to hoist a full load of men, in case of emergency, in an unbalanced condition.

52. All electrical safety devices shall be tested at the beginning of each shift and a record of such tests shall be made and signed by an authorized person * and kept on file at the mine.

SLOPE HOISTS.

53. All electrically operated slope, tail-rope, or endless-rope hoists in mines shall be fitted with adequate controlling devices of approved * design.

UNDERGROUND MOTORS OTHER THAN LOCOMOTIVES.

See rules 3 to 9, and "General Rules of Safety for Underground Stations*" (pp. 13–14), and rule 38.

GENERAL CONSTRUCTION.

54. Motors for use in damp places shall have approved* moisture-resisting insulation.

55. The terminals of motors that operate at potentials* exceeding the limits of low voltage* shall be protected* from accidental contact by insulation or by grounded* coverings. Motors that operate at voltages exceeding medium potential* shall have their terminals entirely within the motor frame or bedplate or an approved* conduit box.

EXPLOSION-PROOF* MOTORS.

56. Explosion-proof* motors shall be such motors as have explosion-proof* casings approved by the Bureau of Mines as permissible for use in gaseous mines.

PORTABLE MOTORS*.

57. The motors and controlling appliances of portable* pumps, hoists, and similar portable* apparatus shall be securely mounted on a common base with the machine that is to be operated. All wiring between the motor and the controlling appliances shall be carried in metallic conduit, and the controlling appliances shall be inclosed in a metallic casing. The use of conduit will not be required if the controlling appliances are mounted upon the motor frame in an approved manner.

58. Mining-machine motors and other motors that use a trailing cable shall be provided where the cable enters the frame of the machine with an approved* means for preventing abrasion of the insulating covering of the cable. An insulating clamp placed within the frame, or protected by an approved* metallic covering, shall be provided for taking all mechanical strains upon the cable. (See also rule 119.)

CONTROL.

59. Every stationary motor* and every portable motor* used underground, except mining machines and drills, shall be protected, together with its starting device, by a fuse in each conductor leading to the motor or by a circuit-breaking device in at least one conductor of direct-current motors and in each conductor of alternating-current motors, and by switches arranged to cut off entirely the power from the motor. The above devices shall be installed in a convenient position in sight of the motor or in sight of the equipment that the motor operates. The controlling appliances of stationary motors,* except the controllers of hoists and similar equipment, shall be mounted upon a switchboard.*

Resistances may be mounted upon a separate metallic framework.

60. Underground motors that operate car or coal-handling equipment shall be provided at a point near such equipment with a switch or other means for disconnecting the motor from the power supply.

61. Underground motors used to drive booster or auxiliary fans shall be so designed or equipped that they will start automatically when their circuits are connected to the power supply.

62. All nonautomatic, current-limiting starting devices, except those used with mining machines, drills, locomotives, and hoists, shall be provided with a no-voltage release.

63. Electrically operated mining machines and drills may be protected by a single fuse and need not be equipped with a line switch if an approved* current-rupturing device is installed at that end of the trailing cable which is nearest to the power supply. If a hook is used for this purpose it shall be provided with an insulated handle of approved* construction. If cable reels are used they shall be provided with an approved* means for opening the circuit under full motor load. (See also rule 123.)

64. All insulating material used in connection with starting resistances shall be noncombustible. This includes the insulation of wire used for the internal wiring of resistances.

65. All switches shall be so installed that they can not close by gravity.

66. Every underground stationary motor* of 100 brake horsepower or over shall be provided with a suitable meter to indicate the amount of load on the machine.

67. All wiring between motors and their controlling appliances shall be insulated.

68. Overload release devices on starting rheostats and compensators will not be considered as taking the place of circuit breakers if such devices are inoperative during the starting of the motor. If automatic starting devices are used they shall be inclosed in a fire-proof inclosure, or mounted upon a metallic framework clear of all combustible material.

LOCOMOTIVES.

69. Electric haulage by locomotives operated from a trolley wire shall not be permitted in any gaseous place* in a mine.

WIRING.

70. The wiring on all locomotives shall be of ample size to carry the current and shall be insulated with rubber or varnished cloth, covered with a double braid, and where space permits shall be incased in approved* metallic conduit, with the exception that any wires that are subjected to high temperatures shall be covered with flame-proof material.

HEADLIGHTS.

71. A headlight shall be placed on each locomotive. If arc headlights are used, an approved* switch shall be provided that will allow the motorman to turn the lights on or off without leaving his seat.

SAND BOXES.

72. Each locomotive shall be provided with sand boxes large enough to contain an ample supply for the run or until such time as the supply can be replenished.

GATHERING LOCOMOTIVES.

73. Gathering locomotives may be operated with a single-conductor trailing cable if the track is thoroughly bonded; otherwise double-conductor trailing cable must be used.

74. The trailing cable of gathering locomotives shall be provided with an approved * insulated hook or other device for making connection to the trolley wire, and if a double-conductor cable is used a similar hook or device shall be provided for making connection to the track rail.

STORAGE-BATTERY LOCOMOTIVES.

75. Storage-battery locomotives may be used in gaseous places* in a mine if the locomotives have been approved as explosion proof * by the Federal Bureau of Mines.

UNDERGROUND TRANSFORMERS.

See "Underground stations *" (p. 13), "Transformer stations" (p. 13), and rules 80 and 81.

DIVISION 4.—CIRCUITS AND CONDUCTORS.

PROTECTION AND CONTROL.

PROTECTION OF ALL CIRCUITS.

76. All circuits shall be provided with current-rupturing devices of such capacity and so installed that the current in any part of the circuit can not exceed the carrying capacity of that part as defined by rule 16.

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PROTECTION OF CIRCUITS LEADING UNDERGROUND FROM GENERATING STATIONS.*

77. Every direct or alternating current circuit leading underground from generating stations * or substations * and operating at a potential * not exceeding the limits of medium voltage * shall be provided above ground with a switch in each conductor and an automatic overload circuit breaker in at least one conductor (the ungrounded side), in the case of direct-current circuits, and in each conductor of alternating-current circuits with trip coils in at least two phases. Each such circuit shall be provided with a suitable ammeter. Where the load on the circuit does not exceed 50 kilowatts, or where it can be shown that the maximum short-circuit current can not exceed 500 amperes, the circuit may be protected by a switch in each conductor provided with National Electric Code fuses of proper capacity and no ammeter need be provided.

78. Every alternating-current feeder circuit leading underground from a generating station* or substation* and operating at a potential* exceeding the limits of medium voltage* shall be provided at the generating* or substation* above ground with a disconnecting switch and an oil-break switch in each conductor, such oil-break switch or switches to be equipped with an automatic overload trip having a trip coil in at least two phases. Each such circuit shall also be provided with a suitable ammeter.

PROTECTION OF BORE-HOLE TRANSFORMERS [a] INSTALLED ON THE SURFACE.

79. Circuits entering bore-hole transformers shall be protected at generating* or substations* as prescribed in rule 78, and shall be protected at the transformer with an oil switch or with approved* air-break switches and fuses. Circuits leaving bore-hole transformers need not be provided with either switches or fuses if these are installed at the places where power is used underground.

PROTECTION OF UNDERGROUND TRANSFORMER CIRCUITS.

80. All transformers shall be equipped with automatic current-interrupting devices in at least the primary side of the transformer; and also in the secondary side of the transformer if the current-interrupting devices in the primary are not readily accessible from the transformer.

81. When the potential* of circuits entering or leaving underground transformers exceeds the limits of medium voltage*, current-interrupting devices shall consist of an oil-break switch in each conductor and each switch shall be provided with an automatic overload trip.

82. When the potential* of circuits entering or leaving transformers does not exceed the limits of medium voltage*, their protective devices may consist of an oil-break switch as described above or of a knife switch and automatic circuit breaker in each conductor, except that approved* fuses may be substituted for circuit breakers.

MAXIMUM RESISTANCE OF CIRCUITS.

83. The resistance of any circuit shall not be so great that a complete short-circuit at any point will fail to operate the current-rupturing device that protects the circuit.

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[a] A bore-hole transformer is a transformer installed out-of-doors on the surface near the bore hole through which the secondary circuit enters the mine.

INSTALLING OF SURFACE CIRCUITS.

SURFACE TRANSMISSION LINES.

84. Power wires shall not be placed on the same cross arms with telegraph, telephone, or signal wires. When placed on the same pole with such wires and below them the distance between the two inside pins of each cross arm carrying power wires shall not be less than 26 inches.

85. Transmission lines operating at potentials* in excess of 5,000 volts shall not be placed on the same poles with telephone circuits that are or can be connected underground unless the telephone lines are provided with approved* protective devices that are capable of preventing the higher voltage from entering the underground telephone circuits.

SURFACE TROLLEY LINES.

86. All surface trolley lines shall be kept at least 6 feet above the top of the rail and shall be protected* at all regularly provided crossings by a guard that will prevent men from coming in contact with the wire either directly or by bringing tools in contact with the wire.

87. That part of the trolley circuit used for surface operations shall be so arranged that it can be entirely disconnected from the power supply without cutting off the current inside of the mine or interfering with the operation of other apparatus not a part of the trolley system.

88. Trolley wires shall not be smaller than No. 0 B. & S. gage copper wire or No. 4 B. & S. gage silicon-bronze wire, and shall withstand easily the strain put upon them when in use.

89. Trolley wires shall have double insulation from the ground unless an approved* single insulator is used. In wooden pole construction the pole will be considered as one insulation.

METHODS OF CARRYING CIRCUITS UNDERGROUND.

SUSPENSION IN SHAFTS.

90. All power conductors installed in shafts shall be covered with approved* insulating material throughout or protected* in an approved manner, and shall be firmly fastened to or suspended from properly supported insulators, unless the conductors are sheathed with lead or inclosed in conduit. Conductors used as returns in shafts for ground-return* systems shall be supported on insulators, but need not be covered with insulation.

91. Shaft cables that are so constructed that the whole or any part of the cable is not self-sustaining shall be supported in an approved* manner at such intervals as may be necessary to prevent the occurrence of undue strains in sheath, insulation, or conductors.

92. Shaft cables shall be so placed or protected that they are not liable to injury from falling material.

SUSPENSION IN BORE HOLES.

93. All power conductors installed in bore holes shall be covered with insulation and supported in an approved* manner that shall prevent the occurrence of undue strains in sheath, insulation, or conductors.

94. Telephone or signal wires shall not be installed in the same bore hole with power wires unless either the signal or the power conductors in the bore hole are incased in metallic coverings that are permanently grounded.*

ENTRANCE OF CONDUCTORS THROUGH DRIFTS OR SLOPES.

95. Low and medium voltage* power conductors in drifts or slopes may be installed bare, but shall be carried on suitable insulators securely fastened to the sides or roof of the entry. If the drift or slope is used for traveling, the conductors shall be protected* as required in rule 102.

INSTALLATION OF UNDERGROUND POWER CIRCUITS AND CONDUCTORS.

96. All joints in wires shall be made electrically and mechanically efficient either by the use of an approved* mechanical connector or by soldering.

97. Underground conductors will not be considered as shock proof* unless they are incased in metallic covering that is thoroughly grounded.*

98. Low and medium voltage* conductors shall be carried at least 6 inches from the trolley line and on the nearest rib side of it, and shall be supported on insulators of an approved* type. When the height of the entry does not exceed 5 feet, the insulators shall be placed not more than 20 feet apart and as much closer as is necessary to support the wires properly.

99. If the height of the entry is more than 5 feet, the insulators shall be placed not more than 30 feet apart and as much closer as may be necessary to support the line properly.

100. High-voltage * conductors shall be carried in metallic coverings and shall be installed in an approved * manner with special reference to the conditions under which they are installed.

101. The negative or return wire of grounded* systems shall be treated in exactly the same manner as the positive or live * wire and afforded the same support and insulation.

102. All conductors in traveling ways, except haulage roads used for traveling (see rule 13) and medium-voltage * conductors in room entries shall be protected * throughout that part of the entry that is used for traveling, unless the conductors are at least 6½ feet above the rail, in which case protection * will be necessary only at those points where men are required to work beneath the conductors or pass under them. The insulators may be supported directly from the roof or side or may be attached to timbers not less than 3 by 4 inches in size or may be secured to steel mine timbers. The insulators shall be placed so that the height of the conductors above the bottom will be comparatively uniform.

103. All conductors shall be strung with the least practicable sag between the supporting insulators and shall be maintained in this condition and kept from contact with rock, coal, timber, or other noninsulating material.

104. All main conductors shall be sectionalized by knife-blade lever switches at points not more than 2,500 feet apart.

105. If there are gaseous places * in the return air courses of a mine, electric circuits shall not be carried in such air courses.

BRANCH CONDUCTORS.

106. Branch conductors shall be supported and maintained in the same manner as main conductors and given the same protection.

107. At the point where branch circuits leave the main circuits there shall be placed a switch that will cut off all current from the branch circuits.

108. The conductors of branch circuits for operating mining machines shall be not smaller than No. 4 B. & S. gage copper wire. The conductors of pump circuits shall be not smaller than No. 8 B. & S. gage.

109. Where wires pass through partitions or wooden or other brattices they shall be protected with porcelain tubes held in place with tape or thoroughly cemented in place so that they can not move.

110. Entries or passageways in which wires are installed must be kept sufficiently free from rock, slate, or other material to permit ready access to the wires at all times.

ROOM WIRING.[a]

111. In gaseous places* rooms shall not be wired and in nongaseous places all room wiring shall be treated as a branch circuit and equipped at the room entrance with switches or some other device that will entirely disconnect the wiring when not in use.

TROLLEY WIRES.

112. Trolley wires shall be of hard-drawn copper not smaller in size than 1/0 B. & S. gage and shall be securely supported on approved * hangers which may be attached directly to the roof or securely fastened to timber or equivalent.

113. The height of trolley wires above the top of the rail shall be made as uniform as practicable and shall in no case be more than 20 per cent above or 20 per cent below the average height.

114. Trolley wires shall be placed at least 6 inches outside of the rail, kept in as straight a line as possible, and installed on the side of the entry opposite from shelter holes or traveling way or space.

115. On straight runs the hangers shall be placed not more than 20 feet apart where the height of the roof above the track is 5 feet or less and not more than 30 feet apart where the roof is more than 5 feet above the track. On curves the hangers shall be placed so close together that the trolley wire at any one hanger may be entirely disconnected without exposing the locomotive runner to danger of contact.

116. Underground trolley lines shall be sectionalized every 2,500 feet by placing in the line a switch by which the line can be entirely disconnected from the power supply. All branch trolley lines shall be provided with a frog at the point where they leave the main and also with a switch installed at or near the frog, by which the branch can be disconnected from the main.

117. Trolley wires that are less than 6½ feet above the top of the rail shall be protected * at all points where men are regularly required to work or pass under them and at all points where men may come in contact with the wires.

BONDING.

118. The tracks of all main haulage systems that use a rail return shall be bonded at every rail joint, and cross bonding shall be placed at intervals not exceeding 200 feet. Special provision shall be made for bonding around all switches, frogs, or openings in the track so as to insure a continuous return.

TRAILING CABLES.

119. Trailing cables for portable machines shall be specially flexible, heavily insulated, and protected with extra stout braiding, hose pipes, or other effective covering. (See also rule 74.)

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[a] The bureau recommends that rooms be not wired.

120. Each trailing cable in use shall be examined daily by the machine operator for abrasion and other defects, and he shall also be required to observe carefully the trailing cable while in use, and shall at once repair any defect or report it to the person in charge of electrical equipment.

121. In the event of the trailing cable in service breaking down or becoming damaged in any way, or any person receiving a shock from it, it shall be at once put out of service. The faulty cable shall not again be used until it has been repaired and tested by an authorized person *.

122. The trailing cable shall be divided at the motor, but only for such length as is necessary for making connection to the motor, and the cable, with its outer covering complete, shall be clamped securely to the motor frame in such a manner as to protect the cable from injury and to prevent any mechanical strain being borne by the single ends that make electrical connection to the motor.

123. In gaseous places* in a mine, a fixed terminal box shall be provided at the points where trailing cables are attached to the power supply. This terminal box shall be explosion-proof* and shall contain a switch and fuse in each conductor of the circuit. The switch shall be so arranged that it can be operated only from without the box when the box is completely closed, and the switch shall also be so constructed that the trailing cables can not be attached or removed when the switch is closed.

LIGHTING CIRCUITS IN NONGASEOUS PLACES.*

See also rules 137 to 139, 141, and 143.

124. Lighting wires shall be attached to power wires by soldering or by fastening under a set screw in a lug attached to the trolley hanger, or by such other devices as will prevent the wires from becoming loose.

125. All wiring shall be supported on noncombustible, nonabsorptive insulators which shall separate the wires by at least an inch from the surfaces wired over. Wires of opposite polarity shall be kept at least 5 inches apart.

126. No wires smaller than No. 14 B. & S. gage shall be used for lighting circuits in nongaseous places.

127. When the ground is used as a return for lighting circuits the return wire shall be attached to the track by bonding to the rail or by attachment to regular bonding in an approved* manner. This ground connection shall be made of not less than No. 8 B. & S. gage copper wire which shall be buried below the surface and carried to the side of the entry and thence on porcelain insulators to the roof or a point at least 5 feet above the track.

LIGHTING CIRCUITS IN GASEOUS PLACES*[a].

See also rules 140, 142, and 144.

128. The potential* of lighting circuits in gaseous places* shall not exceed the limits of low voltage.

129. Lighting circuits in gaseous places* shall consist of conductors inclosed in a metallic sheath permanently grounded* or of insulated wires completely inclosed in metallic conduit permanently grounded* and sealed.

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[a] The Bureau of Mines recommends that in mines in which fire damp is given off, or is liable to be given off, in dangerous quantities the use of lighting circuits be confined to those entries and places that are ventilated by intake air currents which have not passed by or through abandoned or active workings, except that a lighting circuit may be used in a shaft or slope bottom ventilated by a return air current in which the percentage of methane does not exceed 1 per cent.

130. The circuits shall be run from the outside with all switches and protective devices on the surface, or by using switches, fuses, or circuit breakers inclosed in explosion-proof* casings situated underground, or by ventilating with fresh air the place where the switches and fuses are installed .

131. If the circuits are run from the outside with the controlling devices installed on the surface, the conductors leading underground shall be not smaller than No. 8 B. & S. gage and each circuit shall be provided above ground with a suitable ammeter.

132. Each circuit shall have a double-pole switch and fuses or circuit breakers in the case of two-wire systems, and a three-pole switch and fuses or circuit breakers in the case of three-wire systems.

133. The fuses or circuit breakers shall be designed or arranged to operate when the allowable load is exceeded by 25 per cent.

134. No wire smaller than No. 12 B. & S. gage shall be used in lighting circuits in gaseous places* except for the leads of weatherproof sockets, and these shall not be less than No. 14 B. & S. gage.

135. In case distribution is made from a point underground, the distribution switches and fuses shall be mounted on a noncombustible panel mounted in a metal cabinet and fitted with a hinged door. This cabinet shall be used whether explosion-proof* switches are required or not. The cabinet shall be fitted with a door properly hinged so that it will close tightly and shall be provided with a fastening that will hold the door securely in a closed position.

136. Flexible lamp-cord connections are prohibited except for portable lamps,* as covered by rule 145.

DIVISION 5.—MISCELLANEOUS EQUIPMENT.

FIXED ELECTRIC LAMPS.

For wiring and control requirements of fixed electric lamps, see rules 124 to 136, inclusive.

137. Electric lamps used to illuminate haulage roads, side tracks, and similar passageways in nongaseous places* of a mine may be connected to power and trolley lines.

138. Lamps may be connected in multiple or in series, and no fuse or switch will be required for one lamp or series of lamps. A switch may be used if it is desired to switch the lamps on or off and a fuse must be used if it is necessary to protect any considerable length of wire.

139. All sockets shall be of the keyless weatherproof type and have no exposed metallic parts. Lead wires shall be rubber covered and of a size not smaller than No. 14 B. & S. gage. The lead wires shall be made a part of the socket and permanently connected thereto. These wires shall be attached directly to the line wires by soldering or by mechanical connectors. Sockets shall not be supported by the line wires, but by an additional insulator or insulators or some other device that will be entirely independent of the line wires.

140. In mines that contain gaseous places* and in which electricity is used only for lighting or where the lighting circuits are separate from the power circuits, the potential* of such circuits shall not exceed the limits of low voltage* and all lamps shall be connected in multiple.

141. Not more than 24 lamps shall be attached to any one circuit and the power taken by any one circuit shall not exceed 1,300 watts.

142. In gaseous places* of a mine incandescent lamps shall be protected by approved* fittings of strong glass or metal.

143. Incandescent lamps shall be so installed that they can not come in contact with combustible material.

144. Electric lamps shall be replaced by an authorized person* only, and in gaseous places* only after an examination for gas has been made with a safety lamp.

PORTABLE ELECTRIC LAMPS.*

145. Portable incandescent lamps,* other than approved* battery lamps, shall not be used except in connection with the repair and inspection of machines and equipment and then only in nongaseous* places in mines. When so used they shall be protected by a heavy wire cage which completely incloses both lamp and socket and shall be provided with a handle to which both cage and socket are firmly attached and through which the cord supplying the current is carried. The socket shall be keyless and the lamp circuit shall be protected by a fuse.

146. When a portable lamp* is one of several connected in series between a source of potential* and the earth the portable lamp* shall be the one in the series electrically nearest to the earth connection.

147. The use of portable lamps with leads of ordinary flexible cord is prohibited. Only lamp cords approved* for this purpose shall be used.

SELF-CONTAINED PORTABLE ELECTRIC LAMPS.[a]

148. Self-contained portable electric lamps for use in gaseous places* shall be of a type approved as permissible by the Federal Bureau of Mines.

ELECTRIC SHOT-FIRING EQUIPMENT.

149. Electricity from any grounded* circuit shall not be used for firing shots.[b]

150. Special precautions shall be taken to prevent shot-firing conductors from becoming grounded* or from getting in contact with other electric circuits.

151. Only authorized persons* shall be allowed to fire shots with electricity in a mine.

152. The electric detonators or igniters and leads thereto shall be suitable for the conditions under which the blasting is carried on and shall be approved by the Federal Bureau of Mines.

153. Portable shot-firing machines shall be of efficient design and shall be substantially constructed. All such machines shall be inclosed in strong, tight casings.

154. Primary or secondary batteries used for shot-firing shall be inclosed in a well-constructed casing provided with a special form of contact plug for making the connection between the batteries and the shot-firing leads. The

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[a] The use of self-contained portable electric lamps* of suitable design and construction is recommended for all coal mines, provided that in gaseous places or in places where black damp is given off in large quantities frequent inspections with safety lamps are made.

[b] It is recommended that all shots be fired electrically, and that for inside firing shots be fired separately and one at a time on account of the danger of causing blown-out shots and resultant explosions. If fired in groups the firing should be done only from the surface.

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design of the plug shall be such that considerable pressure will be required to make the contact, which will be immediately broken unless the plug is forcibly held in position.

155. There shall be no exposed contacts on the outside of the battery casings.

156. All portable shot-firing machines shall be equipped with a detachable handle, connecting plug, key, or similar approved * device without which the shot-firing circuit can not be closed, and which shall under no circumstances pass from the custody of the person authorized to fire the shots.

157. No shot-firing device shall be connected to the shot-firing leads until all other steps preparatory to the firing of the shot have been completed and all persons have moved to a position of safety.

Disconnection of Leads.

158. Immediately after the firing of a shot the firing leads shall be disconnected from the supply of electricity, and no person shall approach a shot which electricity has failed to explode until the firing leads have been so disconnected and an interval of 10 minutes has elapsed since the last attempt to fire the shot.

Shot Firing From Surface.

159. In coal mines employing the system of firing shots electrically from above ground when everyone is out of the mine, a complete metallic circuit shall be employed and both wires shall be covered with insulation and supported upon glass or porcelain insulators.

160. There shall be a switch at the mouth of each working place so that the circuit can be kept open while the miners are at work and closed only when the shots have been prepared and the miner or miners are leaving the place.

161. There shall be a locked switch in the circuit at the entrance to each heading or side entry which shall be locked open and be thrown in only by an authorized person* when all the men are out of the respective heading or branch entry.

162. There shall be in the circuit at the foot of the shaft or slope two plugs with flexible leads not less than 5 feet long to break further the main circuit of the shot-firing system until all the men in the mine have gone out, when the plugs will be put in by the one man authorized* to do so. Provision shall be made for locking the plugs out of circuit.

163. There shall be located in the power house a locked switch to be used for connecting the shot-firing circuit to the generator or power line. This switch shall be thrown in only by the man who is authorized* to do the shot firing and not until the men have been checked out of the mine.

164. There shall be located in the shot firer's cabin a locked firing switch which shall be thrown only by the authorized* shot firer after all the men are out of the mine and after all other switches have been thrown in. In firing shots, this switch shall be thrown but once.

165. To insure that all men are out of the mine, an approved* system of checking shall be employed.

166. All shot-firing lines shall be carefully insulated and the two wires that form the circuit shall be placed on the side of the entry or passageway opposite from that on which the trolley wire is placed, and so far as possible other roads than the trolley road shall be used for carrying the wires into the working places.

ELECTRIC SIGNALING EQUIPMENT.

167. The parts of electrical signaling systems used in connection with mines shall be designed, constructed, and installed in an approved* manner. No voltage* in excess of 25 volts shall be applied to signal circuits in gaseous places.

168. Signaling equipment that is to be used in any gaseous place* shall be so designed and constructed that no sparks sufficient to ignite gas can be obtained from the operation of the system. Only insulated wire shall be used in gaseous places*.

169. Suitable precautions shall be taken to prevent electric signal or telephone wires from becoming grounded* or from coming in contact with electric conductors, whether insulated or not. Signal circuits and telephone wires shall not be installed on the same side of an entry as power conductors.

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